REMARKS

Claims 1-15 and 17-20 remain in the application. By this amendment claims 4, 5, 14, 15, and 20 have been amended and claim 16 has been canceled without prejudice. Claims 1-3, 6-13, and 17-19 remain in original form.

REJECTION OF CLAIMS 1, 2, 4, 8, 12, 16, AND 19 UNDER 35 U.S.C. § 112, SECOND PARAGRAPH

Claims 1, 2, 4, 8, 12, 16, and 19 were rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. This rejection is respectfully traversed.

The Office action alleges that with regard to claims 4, 8, and 19 the term "process signature" has not been adequately defined. It is respectfully submitted that the term "process signature" is known to those skilled in the art and as such requires no definition. To support this proposition applicants respectfully point out that the term "process signature" is defined in U.S. Patent No. 6,507, 933 as a term known in the industry as a combination of a defect map pattern and defect types. Because the term "process signature" is known in the industry and does not require further definition, claims 4, 8, and 19 particularly point out and distinctly claim the subject matter which applicants regard as the invention. Accordingly, the rejection of claims 4, 8, and 19 under 35 U.S.C. § 112, second paragraph, is believed to be without merit.

The Office action alleges that the term "uncategorized" is unclear with regard to claims 1, 12, and 16 because these claims fail to resolve against what the defect spatial signatures, process anomalies, and defect maps are uncategorized. To support this proposition, the Office action recites an example in which a defect spatial signature may not be categorized according to shape or location, but may be categorized according to other aspects, such as size. The Office action further alleges that such a defect spatial signature can be considered categorized (i.e., not uncategorized) and that conversely, one can consider the spatial signature to be uncategorized, at least, with respect to shape and

location. The Office action then states that this ambiguity arises when broadly distinguishing items as being uncategorized. It is respectfully submitted that the analogy is flawed because it assumes at least one parameter may be categorized. However, in accordance with applicants' invention the defect patterns on the substrate are merely stored in an electronic media, regardless of shape, location, size, or other parameters. In other words, a replica of the defect pattern as it exists on the wafer is stored in for example, a database. There is no attempt to categorize the defects using any parameter, thereby rendering the analogy flawed. Therefore, the rejection is without merit and the rejection of claims 1 and 12 under 35 U.S.C. § 112, second paragraph, is believed to be overcome.

The essence of claim 16 has been incorporated into claim 15 from which it depends. Thus, the rejection of claim 16 under 35 U.S.C. § 112, second paragraph, is moot.

The Office action alleges that claims 2 and 16 are in contradiction with claims 4 and 6. The Office action further states that the word "uncorrelated" will be interpreted as "different." It is respectfully submitted that claims 2, 4, and 6, are consistent with each other and the generally accepted meaning of the word "uncorrelated" applies. In addition, claim 15, which contains the essence of claim 16, is also consistent with claims 2, 4, and 6. Claim 4 calls for, among other things, storing coordinates of a process signature of a first defect and storing coordinates of a process signature of a second defect, wherein the coordinates of the process signatures of the first and second defects are in relation to each other. Claim 6 calls for, among other things, adding the recent defect spatial signature to the defect database. In both instances, the claims set forth storing the relationship of the defects to each other, i.e., how each defect on a wafer is located relative to other defects on the same wafer. Thus, the data stored is not information about the defects or information regarding the correlation of the defects between wafers, but merely the mapping of the defects to indicate that a defect of some sort occurred at a particular point on a wafer. Although applicants believe claim 4 is in conformance with 35 U.S.C. § 112, second paragraph, claim 4 has been amended to further the prosecution of the application on its merits. Thus, it is respectfully submitted that claims 2, 4, and 6 do not conflict with each other and that these claims particularly point out and distinctly claim the subject

matter which applicants regard as the invention. Accordingly, claims 2, 4, and 6 are believed to be in conformance with 35 U.S.C. § 112, second paragraph. Similarly, claim 15, which includes the essence of claim 16, is also believed to be in conformance with 35 U.S.C. § 112, second paragraph.

REJECTION OF CLAIMS 1, 2, 4, 5, 8, 10, 12-14, 16, 19 AND 20 UNDER 35 U.S.C. § 112, FIRST PARAGRAPH

Claims 1, 2, 4, 5, 8, 10, 12-14, 16, 19, and 20 were rejected under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement. This rejection is respectfully traversed.

The Office action alleges that with regard to claims 1, 12, and 16 it cannot be readily determined from the Applicants' disclosure how the defect spatial signatures, process anomalies, and defect maps are uncategorized. It was stated that these items seemed to be categorized, for example, as being attributable to certain process steps. It is respectfully submitted that this interpretation of the claim language redefines the term "defect spatial signature" to include more than the process signature, but to also include the sources of the defects. The Office action then alleges that the sources of the defects are categorized. This use of the term "defect spatial signature" and the attempt to categorize the sources of the defects is inconsistent with the definition of the term "defect spatial signature" and with the language of claim 9. The Office action then alleges that the sources of the defects are categorized. Accordingly, it is believed that claim 9 is in conformance with 35 U.S.C. § 112, first paragraph.

It was further stated that it seems, at least implicitly, that these defects require categorization in order for the Applicants' claimed method to operate as intended. Applicants' teach on page 3, lines 3-4, that the present invention provides a method for determining whether a particular defect on a semiconductor wafer has been encountered previously. It is respectfully pointed out that determining whether a defect has occurred in the past does not require categorizing the defects. Accordingly, it is believed claims 1 and 12 are in conformance with 35 U.S.C. § 112, first paragraph. Likewise, claim 15,

which contains the essence of claim 16 is also believed to be in conformance with 35 U.S.C. § 112, first paragraph.

The Office action states that claims 2, 10, and 16, respectively, propose that the defect signatures, process anomalies, and defect maps are uncorrelated and that applicants contradict these claims by stating that the wafer map of the first wafer is reconstructed from the relational database (reference number 29) and the wafer maps of the two wafers are electronically analyzed to determine if the wafer map of the first wafer correlates to that of the second wafer within a predetermined confidence level (reference number 31). If a match within the predetermined confidence level occurs, then the computer reports that a match has been encountered. The engineer is notified and can then review the process history of the first wafer with that of the second wafer to discover at which step in the process the defect occurred. It is respectfully submitted that the defect maps are neither characterized nor correlated before storage in the database. Rather, they are stored in the database. In accordance with an embodiment of the present invention, when a new defect map is generated the database containing the uncorrelated and uncategorized defect maps is searched to determine if the new defect map matches one of the stored defect maps to within a predetermined confidence level. Thus, it is respectfully submitted that applicants' claims and specification are not contradictory and that applicants comply with the enablement requirement of 35 U.S.C. § 112, first paragraph.

The Office action alleges that claims 4, 8, 13, and 19 lack support in the specification. The specification has been amended to provide support for "storing coordinates" thereby overcoming the 35 U.S.C. § 112 first paragraph rejection.

The Office action alleges that claims 5, 14, and 20 lack support in the specification. Although applicants believe the statement in the Office action that "[a] cluster of defects and a local density of defects can scarcely be considered the same" is inaccurate, the specification and claims 5, 14, and 20 have been amended in an effort to further the prosecution of the application. Support for the proposition regarding the accuracy of the statement is based in part on U.S. Patent No. 5,831,865 which discusses clusters and local density of defects. The amendment to the specification is believed to overcome the 35 U.S.C. § 112 first paragraph, rejection.

In view of all of the above, applicants believe the application is in conformance with 35 U.S.C. § 112, first paragraph, and that the application is in condition for allowance.

REJECTION OF CLAIMS 1, 2, 10-12, 15, AND 16 UNDER 35 U.S.C. § 102(e)

Claims 1, 2, 10-12, 15, and 16 were rejected under 35 U.S.C. § 102(e) as being anticipated by Ferrell et al. This rejection is respectfully traversed.

Ferrell et al. teach in column 1, lines 32-67, and continuing to column 2, lines 1-30, that image knowledge structure and an access method for retrieving images are two significant problems in the design of large intelligent image database systems. Content-based image retrieval [CBIR] represents a promising and cutting-edge technology useful in addressing the problem of high-speed image storage and retrieval. Specifically, CBIR refers to techniques used to index and retrieve images from databases based on their pictorial content. Typically, pictorial content is defined by a set of features extracted from an image that describes the color, texture, and/or shape of the entire image or of specific objects. This feature description is used in CBIR to index a database through various means such as distance-based techniques, rule-based decision making, and fuzzy inferencing. Yet, to date, no significant work has been accomplished to apply these technologies to the manufacturing environment. Notwithstanding, imagery collected from the manufacturing processes have unique characteristics that can be taken advantage of in developing a manufacturing-specific CBIR approach. ... Semiconductor manufacturing is representative of an industry that has a mature computer vision component for the inspection of product. Digital imagery for failure analysis is generated between process steps from optical microscopy and laser scattering systems and from confocal, SEM, atomic force microscope and focused ion beam imaging modalities. This data is maintained in a yield management database and used by fabrication engineers to diagnose and source manufacturing problems, verify human assertions regarding the state of the manufacturing process, and to train inexperienced personnel on the wide variety of failure mechanisms observed. Yet, the semiconductor industry currently has no direct means of searching the yield management database using image-based queries. The

ability to query the fabrication process is based primarily on date, lot, and wafer identification number. Although this approach can be useful, it limits the user's ability to quickly locate historical information. For example, if SEM review has determined that a particular defect or pattern problem exists on a wafer, the yield engineer must query on dates, lots, and wafers to find similar historical instances. Although roughly 70% of all space occupied in the database consists of imagery, queries to locate imagery are manual, indirect, tedious, and inefficient. Therefore, this becomes an iterative and slow process that can prove unwieldy in the modern semiconductor environment where a single manufacturing campus having multiple fabrication facilities at one site can generate thousands of images daily. If a query method can be designed that allows the user to look for similar informational content, a faster and more focused result can be achieved. A process for locating similar imagery based on image content, for example the image structure rather than the lot number, wafer identification, and date, would result in a reduced time-to-source.

Ferrell et al. teach in column 4, lines 64-67, and continuing to column 5, lines 1-50, that first the image feature extraction module 2 can represent query and database images 8 in terms of a small number of numerical descriptors. Specifically, the image feature extraction module 2 can receive as an input, image 8. The image feature extraction module 2 can survey the image 8 deriving a vector of numerical descriptors corresponding to the image 8. Unlike prior CBIR systems, in the preferred embodiment, the manufacturing imagery can be described in terms of three independent sets of characteristics shown in FIG. 2. Specifically, the manufacturing image can be characterized in terms of image modality and overall characteristics, substrate-background characteristics, and anomaly-defect characteristics. Moreover, the characteristics used to describe the modality, background, and defect are based on the texture, color, and shape of the image. In the preferred embodiment, the image feature extraction module 2 pre-processes every image in the image database 5 to generate a series of vectors having these descriptive set of features, each vector weighted to a particular characteristic of the stored image. Subsequently, the image feature extraction module 2 can store each of the series of vectors in a corresponding feature vector list 7, contained as part of the image database 5.

The second module forming the manufacturing-specific CBIR system 1, an indexing module 3, can generate a series of hierarchical search 6, each binary search hierarchical search tree 6 corresponding to a particular characteristic of a stored image. Specifically, the indexing module 3 can read a vector of numerical descriptors contained in a particular feature vector list 7, the vector corresponding to an image 8 stored in the image database 5. Subsequently, using an unsupervised clustering method, the indexing module 3 can create and insert a node containing the vector into a hierarchical search tree 6 keyed on the same image characteristic as the feature vector list 7. The indexing module 3 can perform the node insertion operation for each feature vector list 7 stored in the image database 5. Thus, each resulting hierarchical search tree 6 can provide for the rapid location of candidate imagery in the image database 5, each hierarchical search tree 6 weighted to a particular image characteristic.

The third module forming the manufacturing-specific CBIR system 1, a querying module 4, can accept a query image from a user and can return to the user, a collection of similar images stored in the image database 5. Specifically, the querying module 4 can perform an appropriate first level data reduction based upon the query image's associated vector of numerical descriptors. Significantly, the image feature extraction module 2, using the query image as an input, can generate the associated vector of numerical descriptors. Using the vector of numerical descriptors as a guideline, a very rapid traversal of indexing tree 6 in the first-level data reduction routine can produce a preliminary selection of matching images from the image database 5.

Ferrell et al. teach in column 9, lines 8-56, that by using defect masks, the image feature extraction module 2 can develop each feature vector in step 16 by isolating the corresponding characteristic. Notably, the inventive method can further employ a defect filling technique to facilitate description of the background region of an image by removing the defect region based on an estimate derived from the surrounding regions. This defect filling method allows the background to be mathematically described so that other similar background geometries and structures can be retrieved. Subsequently, in step 18, each resulting feature vector can be added to a feature vector list 7. If in decision step 20, additional images remain to be characterized by the image extraction module 2, the process can repeat in step 12, wherein the image extraction module 2 can load another

image 8 stored in the image database 5. However, in decision step 20, when no images 8 remain to be processed, passing through jump circle B to FIG. 3B, the manufacturing-specific CBIR system 1 can form a hierarchical search tree for sorting and storing each feature vector contained in each feature vector list 7.

Having created a series of feature vector lists 7 for images 8 stored in image database 5, the manufacturing-specific CBIR system 1 can initiate an indexing process which organizes the data into a hierarchical tree structure 6 allowing for rapid retrieval of imagery during the query process. Specifically, the manufacturing-specific CBIR system 1 employes feature indexing--a process by which the manufacturing-specific CBIR system 1 organizes feature vectors contained in each feature vector list 7 to facilitate rapid access and retrieval of similar imagery. The indexing technique is critical to the efficient retrieval of similar data from the software system. Unlike existing CBIR systems, the manufacturing-specific CBIR system 1 utilizes a sequential, agglomerative, hierarchical, non-overlapping [SAHN] algorithm for sorting the features contained in the feature vector list 7. Historically, the SAHN algorithm has been used as an investigative tool for unsupervised clustering pattern recognition problems. For the CBIR application, SAHN algorithms are used to quickly reduce the number of feature vectors, v_i, that must be compared to the query vector, Q_v during a retrieval operation.

FIG. 6 shows a schematic representation of a hierarchically ordered set of feature vectors 106, v_i, i=1, 2, ... 9. In the illustrated hierarchy, the vectors forming vector pair (v_3, v_1) have the most similar features to one another. Similarly, the features represented by vector pair (v_2, v_5) also have the most similar features to one another. The next closest pair of vectors (L_1, v_7) maintain a lesser degree of similarity than vector pair (v_3, v_1), where L_1 102 is the prototype of (v_3, v_1) at level 1 defined by the vector average, $\langle v_3, v_1 \rangle$. Applicants, on the other hand, teach on page 3, lines 8-28, a method for electronically searching a database to determine if a spatial signature has occurred before and, if so, notifying an engineer. ... In a beginning step identified by reference number 21, an electronic wafer map for a first wafer having a defect associated therewith is generated. In a next step (reference number 23), the electronic wafer map of the first wafer is partitioned into defect regions or areas by identifying local densities of defects, i.e., the defects are clustered using mathematical clustering techniques or using a stylus and a

pad. Briefly referring to FIG. 4, a wafer map 16 of a defect spatial signature having a cluster boundary 17 is illustrated. The clustering is accomplished using a stylus and pad coupled to a computer system displaying an image of the defect spatial signature. By way of example, the defects are caused at a furnace operation in a semiconductor manufacturing process. The wafer map is stored in a relational database (reference number 25), such that the relationship of the defects to each other are stored in a row and column format. In other words, coordinates of the process signature for each defect are stored in the database thereby creating a relational database. For example, the coordinates of the process signature of a first defect are stored in the relational database and the coordinates of the process signature of a second defect are stored in the relational database. The wafer map of the first wafer is reconstructed from the relational database (reference number 29) and the wafer maps of the two wafers are electronically analyzed to determine if the wafer map of the first wafer correlates to that of the second wafer within a predetermined confidence level (reference number 31). If a match within the predetermined confidence level occurs, then the computer reports that a match has been encountered.

Accordingly applicants' claim 1 calls for, among other things, creating a defect database of wafers having defect spatial signatures, wherein the defect spatial signatures in the defect database are uncategorized data and determining if the recent defect spatial signature corresponds to at least one of the defect spatial signatures of the defect database. Claim 10 calls for, among other things, generating a database of process anomalies, wherein the process anomalies are uncorrelated and determining if the at least one process anomaly corresponds to a process anomaly in the database of process anomalies. Claim 15 calls for, among other things, storing a plurality of defect maps in a storage device, wherein the defect maps are uncorrelated and uncharacterized and determining if the defect map of the recent anomalous event corresponds to one of the plurality of defect maps in the storage device. At least these elements of claims 1, 10, and 15 are not included in the relied on reference of Ferrell et al. Because all elements of applicants' claims 1, 10, and 15 are not included in the relied on reference of Ferrell et al., it cannot anticipate applicants' claims 1, 10, and 15.

Claim 2 depends from claim 1 and is believed allowable over the relied on reference of Ferrell et al. for at least the same reasons as claim 1. Claim 2 further sets out that the defect database contains uncorrelated data. At least this limitation of claim 2 is not included in the relied on reference of Ferrell et al., further precluding anticipation of applicants' claim 2.

Claims 11 and 12 depend from claim 10 and are believed allowable over the relied on reference of Ferrell et al. for at least the same reasons as claim 10. Claim 12 further sets out that the anomalies are uncategorized. At least this limitation of claim 12 is not included in the relied on reference of Ferrell et al., further precluding anticipation of applicants' claim 12.

Claim 16 has been canceled without prejudice. Accordingly, the rejection of claim 16 is moot.

REJECTION OF CLAIMS 3-5, 8, 13, 14, AND 18-20 UNDER 35 U.S.C. § 103(a)

Claims 3-5, 8, 13, 14, and 18-20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Farrell et al., in view of La et al. (U.S. Patent No. 5,761,064). This rejection is respectfully traversed.

Claims 3-5 and 8 depend either directly or indirectly from claim 1 and are believed allowable over the relied on references, either singly or in combination, for at least the same reasons as claim 1.

Claims 13 and 14 depend either directly or indirectly from claim 10 and are believed allowable over the relied on references, taken alone or together, for at least the same reasons as claim 10.

Claims 18-20 depend either directly or indirectly from claim 15 and are believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 15.

REJECTION OF CLAIM 6 UNDER 35 U.S.C. § 103(a)

Claim 6 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Ferrell et al. in view of Jain et al. (U.S. Patent No. 5,893,095). This rejection is respectfully traversed.

Claim 6 depends from claim 1 and is believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 1.

REJECTION OF CLAIMS 7, 11, AND 17 UNDER 35 U.S.C. § 103(a)

Claims 7, 11, and 17 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Ferrell et al. in view of Tobin et al. (U.S. Patent No. 6,535,776). This rejection is respectfully traversed.

Claim 7 depends from claim 1 and is believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 1.

Claim 11 depends from claim 10 and is believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 10.

Claim 17 depends from claim 15 and is believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 15.

REJECTION OF CLAIM 9 UNDER 35 U.S.C. § 103(a)

Claim 9 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Ferrell et al. in view of the Applicants' admitted prior art, as disclosed in the Applicants' Background of the Invention. This rejection is respectfully traversed.

Claim 9 depends from claim 1 and is believed allowable over the relied on references, either alone or in combination, for at least the same reasons as claim 1.

CONCLUSION

No new matter is introduced by the amendments herein. Based on the foregoing, applicants believe that all claims under consideration are in condition for allowance. Reconsideration of this application is respectfully requested.

Respectfully submitted,

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